State of the Ocean: Placentia Bay-Grand Banks Large Ocean Management Area

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STATE OF THE OCEAN: PLACENTIA BAY-GRAND BANK LARGE OCEAN MANAGEMENT AREA

by

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ABSTRACT

DFO 2012. State of the Ocean for the Placentia Bay - Grand Banks Large Ocean Management Area. Can. Manuscr. Rep. Fish. Aquat. Sci. 2983: viii + 34 p.

State of the Ocean (SOTO) reporting for Large Ocean Management Areas (LOMAs) is one tool that can provide oceans managers with the most up-to-date and required scientific and human use information to assess the current status of LOMAs throughout Integrated Management (IM) delivery, when provided on a regular basis. The Placentia Bay Grand Banks (PBGB) LOMA is the designated IM area for the Newfoundland and Labrador (NL) Region. Geographically, the LOMA encompasses an area of approximately 550,000 km², starting at Cape Ray on the island portion of the south coast (near Port aux Basques), continuing eastward along the south coast and extending northward along the east coast, as far north as Cape Freels at the tip of Bonavista Bay. The seaward boundaries correspond with the Northwest Atlantic Fisheries Organization's (NAFO) fisheries management Div. 3LNO and Subdiv. 3Ps and 3Pn. The southern boundary of the LOMA extends beyond the 200 nm limit of Canada's exclusive economic zone to the edge of the continental shelf, defined as 42°N latitude. Several areas for priority conservation action have been identified within the LOMA to date: Atlantic cod, aquatic invasive species (AIS), habitat and corals and sponges. All three of the Atlantic cod (*Gadus morhua*) stocks within the LOMA declined significantly in the late 1980s and early 1990s and are currently marginally above (7 %) to 90 % below the stock-specific Limit Reference Point (LRP). The aquatic invasive species, green crab (*Carcinus maenas*), was first observed in Placentia Bay in 2007, and in areas of high abundance have had a substantial impact on commercial and non-commercial mollusc and crustacean species and the natural environment. Mitigation by removal through intense trapping can be an effective method of reducing the abundance of green crab and limiting the impact the species has on the environment while other methods continue to be researched and tested. The identification of ecologically significant species that provide structural habitats (e.g., corals and eelgrass), areas considered ecologically and biologically significant, as well as habitat characterization remain a priority to enhancing knowledge and protection of areas within the LOMA that are important to the ecosystem structure and function. Deep-sea corals have been identified as ecologically significant species within LOMA ecosystems as they provide unique structural habitat. At the same time, cold water sponges are increasingly being recognized as similarly important components of marine ecosystems through their provision of benthic habitat. Priority research areas for deep-sea corals based on areas of high biodiversity and abundance have been identified in the region and management measures targeting their protection are ongoing. A major shift in community structure occurred along the entire shelf, including the LOMA, in the early 1990s, including a decrease in target and non-target groundfish abundance, a dramatic increase in the biomass of invertebrates, the loss and lack of recovery of capelin, as well as the continued increase in the harp seal population. In regards to new sources of information addressing knowledge gaps within the LOMA, a 2007 aerial

survey was conducted to accurately estimate the abundance and distribution of marine mammals, sea turtles and other surface megafauna with significant impacts for our understanding from a management and Species at Risk perspective.

RÉSUMÉ

DFO 2012. State of the Ocean for the Placentia Bay - Grand Banks Large Ocean Management Area. Can. Manuscr. Rep. Fish. Aquat. Sci. 2983: viii + 34 p.

Les rapports sur l'état de l'océan, lorsqu'ils sont produits régulièrement, représentent l'un des outils qui peut fournir aux gestionnaires des océans l'information la plus à jour ainsi que les renseignements scientifiques et les données sur l'utilisation par les humains nécessaires pour évaluer l'état actuel des zones étendues de gestion des océans (ZEGO) dans un contexte de gestion intégrée (GI). La ZEGO de la baie de Plaisance – Grands Bancs est la zone désignée (GI) pour la Région de Terre-Neuve et du Labrador. Sur le plan géographique, la ZEGO, qui est d'une superficie d'environ 550 000 km², s'étend du cap Ray sur la partie insulaire de la côte sud (près de Port aux Basques), va vers l'est le long de la côte sud ainsi que vers le nord le long de la côte est et remonte aussi loin au nord que le cap Freels, à l'extrémité de la baie de Bonavista. Les limites du côté de la mer correspondent aux divisions 3LNO et aux sous-divisions 3Ps et 3Pn de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO). La limite sud de la ZEGO s'étend au-delà de la limite de 200 NM de la zone économique exclusive du Canada jusqu'au bord du plateau continental (42° de latitude nord). Plusieurs éléments nécessitant des mesures de conservation prioritaires ont été relevés dans la ZEGO jusqu'à maintenant : la morue franche, les espèces aquatiques envahissantes (EAE), l'habitat, les coraux et les éponges. Les trois stocks de morue franche (*Gadus morhua*) présents dans la ZEGO ont connu d'importants déclins à la fin des années 1980 et au début des années 1990; ils se situent à l'heure actuelle légèrement au-dessus (7 %) du niveau correspondant à 90 % du point de référence limite (PRL) du stock. Le crabe vert (*Carcinus maenas*), espèce aquatique envahissante, a été observé pour la première fois dans la baie de Plaisance en 2007 et, dans les zones où son abondance est élevée, il a eu un impact important sur les espèces de mollusques et de crustacés visés ou non par la pêche commerciale ainsi que sur l'environnement naturel. Des mesures d'atténuation, comme la capture intensive au moyen de cages, peuvent représenter une méthode efficace pour réduire l'abondance du crabe vert et pour limiter l'impact de l'espèce sur l'environnement pendant que d'autres méthodes font l'objet d'études et d'essais. La désignation d'espèces d'importance écologique qui fournissent des habitats structuraux (p. ex. coraux et zostère) et de zones d'importance écologique et biologique ainsi que la caractérisation de l'habitat demeurent une priorité pour accroître les connaissances et la protection des zones qui, au sein de la ZEGO, sont importantes pour la structure et les fonctions de l'écosystème. On a désigné des coraux des eaux profondes en tant qu'espèces d'importance écologique dans

l'écosystème de la ZEGO car ils fournissent un habitat structural unique. Au même moment, on met de plus en plus l'accent sur le fait que les éponges d'eaux froides sont des composants de l'écosystème marin aussi importants puisqu'ils fournissent un habitat benthique. Dans la région, on a relevé des domaines de recherche prioritaires pour les coraux des eaux profondes dans les secteurs où on a observé une grande biodiversité ainsi qu'une abondance élevée; des mesures de gestion visant à protéger les coraux ont été mises en œuvre. Au début des années 1990, une importante variation de la structure des communautés s'est produite le long du plateau continental en entier, y compris dans la ZEGO; on a notamment constaté une diminution de l'abondance des poissons de fond exploités et non exploités, une augmentation marquée de la biomasse des invertébrés, une baisse et l'absence de rétablissement des populations de capelan ainsi qu'une augmentation continue de la population de phoques du Groenland. Pour combler les lacunes dans les connaissances sur la ZEGO, un relevé aérien effectué en 2007 nous a grandement aidés, du point de vue de la gestion et des espèces en péril, en nous permettant d'estimer avec précision l'abondance et la répartition des mammifères marins, des tortues de mer et d'autres espèces de la mégafaune vivant en surface.

INTRODUCTION

In the past, fisheries and oceans management has focused on managing single ocean activities independent of other human activities. Such an approach failed to consider the cumulative impacts of all of these activities on the ecosystem and the advantages that could be achieved through regulatory efficiency and opportunities for co-operation. As a result, decisions about ocean resources typically proceeded independently of each other. Canada's commitment to IM was first formulated in the *Oceans Act*, which came into force in 1997, and *Canada's Oceans Strategy* responds to this requirement, providing for an integrated approach to ocean management, coordination of policies and programs across governments, and an ecosystem approach.

The overall purpose of IM is for decision makers responsible for ocean-based activities to manage these activities in a manner that will sustain a healthy marine environment and provide due consideration of other ocean users. There are several important issues and challenges affecting Canada's marine environment, including: declining fish stocks; changes in the structure of marine ecosystems, especially in the upper layers of the food web; introduction of pollutants (such as oil and bilge water) and invasive species (such as green crab); increasing numbers of marine species at risk; habitat alteration and degradation; contamination of traditionally harvested resources; and declining biodiversity and productivity (http://www.dfo-mpo.gc.ca/oceans/management-gestion/healthyoceans-santedesoceans/purpose-but-eng.htm). At the same time, ocean usage by humans is on the increase and is diversifying.

Currently, five priority LOMAs have been established within Canada to focus on areas under pressure from human activities and to address key conservation challenges. Within these planning units, IM is at various stages of being applied. Lessons learned from applying the IM planning approach within these areas will be useful to broadening the approach elsewhere, and it is expected that the IM approach will, in the very near future, be applied across all marine waters under Canada's jurisdiction (i.e., with focus in some areas on the 12 Canadian Marine Bioregions).

LARGE OCEAN MANAGEMENT

The initial assessment of a LOMA includes gathering scientific information about the ecosystem as well as information on the social, economic and cultural features. Under the Ocean's Action Plan (2005-07), science-based evaluations of the ecosystems within LOMAs identified ecologically and biologically significant areas (EBSAs), ecologically significant species and community properties (ESSCPs), Depleted and Rare Species and, ultimately, science-based Conservation Objectives (COs) specific to each LOMA. These objectives, in conjunction with the social, economic and cultural objectives, provide the

information required to guide management approaches for conservation and development activities within the LOMAs.

Governance structures with defined roles and responsibilities also exist for LOMAs, and usually include a committee of decision-makers with authority to conserve and protect ocean ecosystems or manage access to ocean resources (e.g., Federal and Provincial governments), as well as an advisory committee that includes stakeholders such as environmental and community groups, Aboriginal interests, academia and industry. Through these, the development and implementation of an IM plan for LOMAs is intended to be an adaptive process, whereby strategies and plans may change as knowledge is gained through ongoing monitoring and reporting.

SOTO reporting for LOMAs is one tool that can provide oceans managers with the most up-to-date and required scientific and human use information to assess the current status of LOMAs throughout IM delivery, when provided on a regular basis. It is expected that LOMAs will address this type of reporting in manners that will typically target specific requirements at the Regional IM level, often with consideration of, and complimentary to ongoing reporting measures related to existing Science activities in an effort to keep duplication of effort at a minimum.

PLACENTIA BAY GRAND BANKS (PBGB) LOMA

The PBGB LOMA (Fig. 1) is the designated IM area for the NL Region. Geographically, the LOMA encompasses an area of approximately 550,000 km^2, ranging from the Laurentian Channel in the southwest to the Grand Banks in the east, and from the coastal baselines as defined by international law to the outer limits of the continental shelf. For the most part, the PBGB LOMA consists of the Grand Banks of Newfoundland, but with LOMA boundaries including areas both inside and outside of the Exclusive Economic Zone (EEZ) this also includes slope and abyssal zones. The majority of the banks are between 51-100 m in depth with some areas of the banks reaching up to 200 m. On the Grand Banks the cold Labrador Current mixes with the warm Gulf Stream causing an upwelling of nutrients, creating a highly productive area with rich primary productivity and high species diversity. It is this productivity, paired with other available resources (e.g., oil and gas) and geographic location, which also inherently makes this area of the Newfoundland and Labrador region extremely distinctive in its support of human activities.

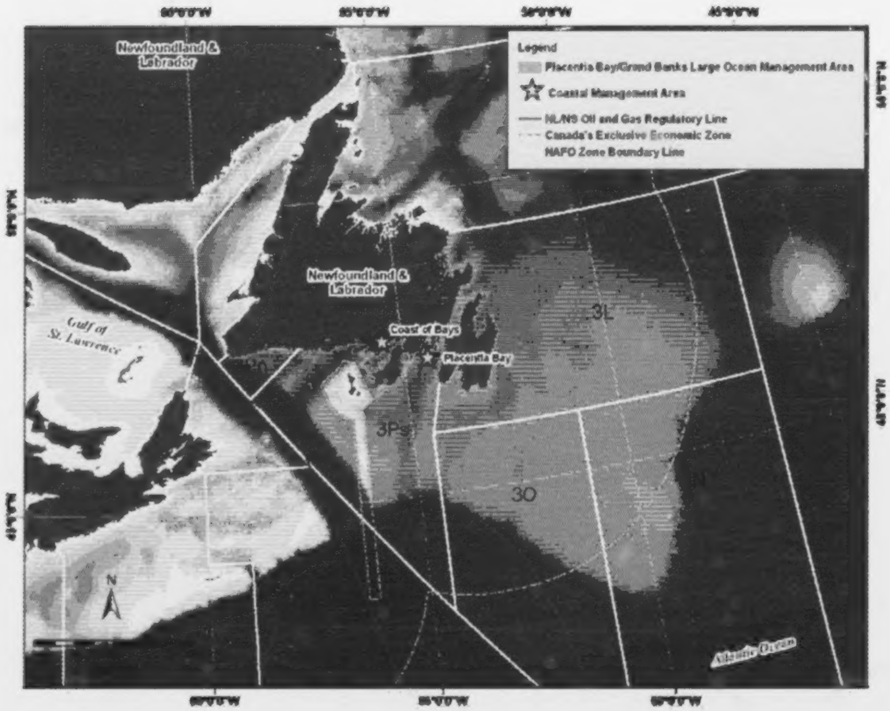


Figure 1. Placentia Bay-Grand Banks Large Ocean Management Area (provided by Ecosystems Management, Newfoundland and Labrador Region).

Conservation Objectives

Based on the identification of 11 EBSAs, 22 ESSCPs, and 13 depleted and rare species, a total of 94 specific COs were identified by DFO Science for the PBGB LOMA. From an ecological perspective, 59 were considered to be high priority, 15 were considered to be medium priority, and 20 were considered to be low priority. A total of 8 overarching and blanket COs were also identified for the LOMA (DFO 2007).

Science advice in the form of COs must be based on the best information available, even if that information is dated and/or incomplete. However, additional information from research-in-progress, upcoming research and the grey literature could have a significant effect on the identification of future conservation priorities. Therefore, DFO Science should be vigilant to monitor changes in additional properties and management should be responsive to major changes in them, even if the ecological significance of each change is not fully understood.

Conservation Priorities

Based on a qualitative threat assessment of the existing COs, and through stakeholder consultation with the PBGB LOMA Working Group, several areas for priority conservation action were identified in 2009. These included: Atlantic cod, aquatic invasive species (specifically green crab control), habitat, and corals and sponges.

State of the Ocean Reporting

Based on the conservation priorities identified for the PBGB LOMA, state of the ocean reporting within the NL Region will focus on the current status and trends of baseline physical and biological oceanographic conditions, as well as summaries of the most recent (usually within the past year) peer-reviewed science information as it most closely relates to those identified priorities. Additionally, new and emerging information that may be relevant to oceans managers (i.e., science addressing data gaps, threats and impacts to ecosystem health) in the near future will also be highlighted in state of the ocean reporting through descriptions of new and/or updated information and anticipated or upcoming areas of research in the NL Region and the LOMA.

OCEANOGRAPHIC STATUS AND TRENDS

The Atlantic Zonal Monitoring Program (AZMP) was created in 1999 as a comprehensive oceanographic monitoring program developed in order to increase DFO's ability to understand the state of the ocean environment and marine ecosystems. Data collected include biological, chemical, and physical field data that will allow for a better understanding and prediction of changes in ocean state, for example in relation to climate change or environment-fisheries interactions.

PHYSICAL OCEANOGRAPHIC CONDITIONS

Physical oceanographic conditions are reported annually for the NL Region. Important climactic factors such as sea ice cover, salinity, water, and air temperature are compiled and compared to historic data in order to determine any major trends in climate change or physical ecosystem characteristics. Additional information to the summary below can be found in Colbourne et al. 2011.

The North Atlantic Oscillation (NAO) index is a key indicator of climate conditions in the Northwest Atlantic. Variations in the NAO can affect ice flow, ocean temperature, the strength of the Labrador Current, and the distribution and

biology of marine species. A high NAO index generally indicates colder water temperatures, stronger northwest winds, cooler air temperatures, and heavy ice sea conditions.

Beginning in the 1970s the NAO index increased and remained in a persistent positive phase for the majority of the 1980s and 1990s (Parsons and Lear 2001 in Templeman 2010), accounting for a substantial part of the observed cooling in the northwest Atlantic (Hurrell and van Loon 1997 in Templeman 2010). The NAO index for 2010 was at a record low and as a consequence, outflow of arctic air masses to the Northwest Atlantic was much weaker than normal. This resulted in a broad-scale warming throughout the Northwest Atlantic from West Greenland to Baffin Island to Newfoundland relative to 2009.

Sea ice extent and duration on the NL Shelf decreased in 2010 for the fifteenth consecutive year, with the annual average reaching a record low (Fig. 2). The International Ice Patrol of the US Coast Guard reported that only one iceberg drifted south of 48°N onto the Northern Grand Bank during 2010 compared with 1204 in 2009.

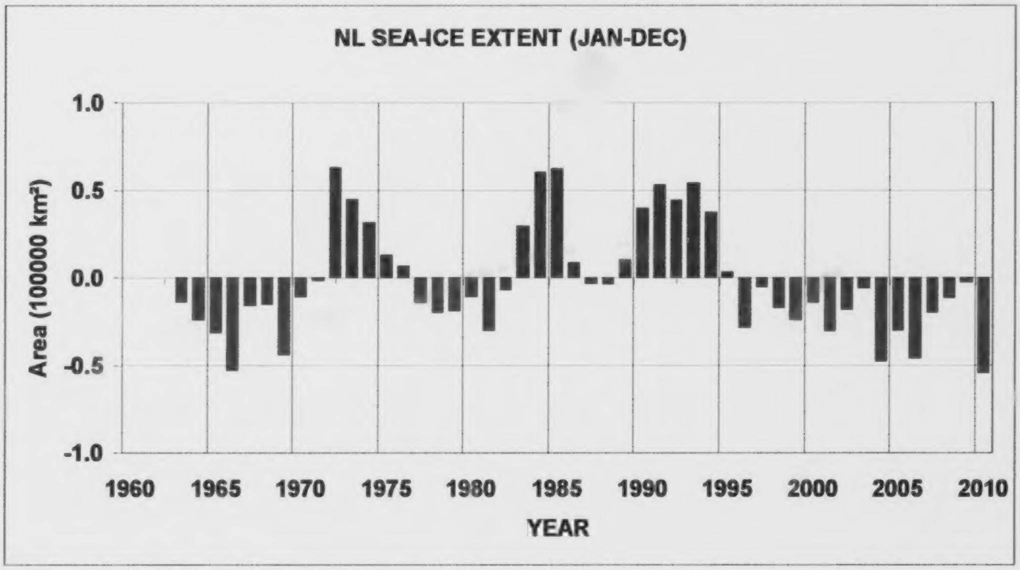


Figure 2. The annual sea-ice areal extent anomalies on the Newfoundland and southern Labrador Shelf relative to the 1981-2010 means (NAFO 2011a).

Water temperature, especially, has a very important influence on the distribution of marine animals. Since species, and the prey that they require, are adapted to specific temperature ranges, temperature changes are likely to have an effect on the distribution and life history patterns of specific species. Biological changes due to fluctuations in temperature might include changes to growth rates, reproduction, or biochemistry, and in turn, affect population structure,

recruitment, and mortality of fish and other species. Over the last four decades the changing water temperatures are thought to be responsible for some of the major changes in distribution and abundance of important commercial species (Scott 1982; Colbourne and Murphy 2002 in Templeman 2010).

At Station 27, a standard monitoring site off Cape Spear, the 2010 depth-averaged annual water temperature increased 0.7 °C (2 standard deviations (SD) above normal), making it the second highest on record (Fig. 3). Annual surface and bottom temperatures (Station 27) were also above normal by 0.6 °C (1 SD) and 0.64 °C (1.7 SD) respectively. The area of <0 °C cold-intermediate-layer (CIL) water mass measured along transects on the eastern Newfoundland Shelf remained below normal (indicating warmer than normal water temperatures) with the Grand Banks transect along 47°N displaying the second lowest on record (Fig. 4). Spring bottom temperatures in NAFO Div. 3Ps and 3LNO during 2010 were above normal by up to 1 SD and as a result the area of the bottom habitat covered by water <0 °C was significantly below normal.

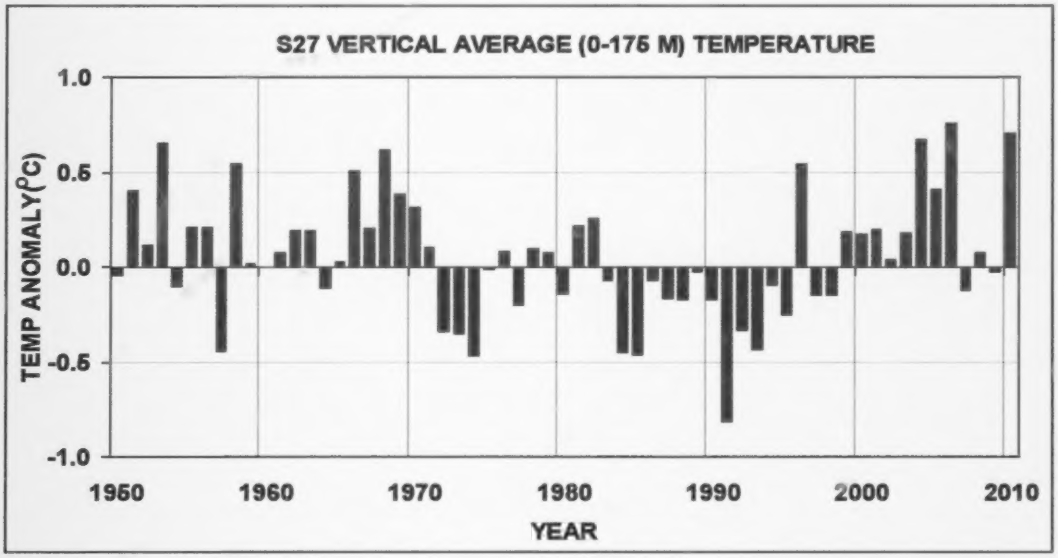


Figure 3. Annual vertically averaged temperature (0-176 m) anomalies at Station 27 referenced to the 1981-2010 mean (NAFO 2011*b*).

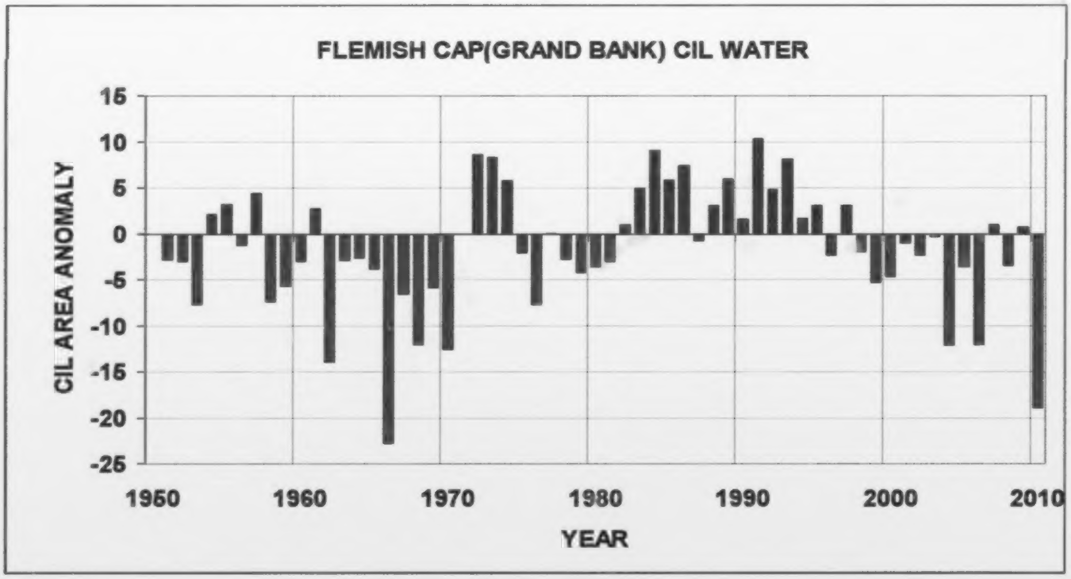


Figure 4. Summer CIL (T<0 ºC) area anomalies along the Grand Banks transect (47ºN) referenced to the 1981-2010 mean (NAFO 2011a).

BIOLOGICAL AND CHEMICAL OCEANOGRAPHIC CONDITIONS

Biological and chemical oceanographic conditions are also assessed annually within the NL Region. Information related to phytoplankton (microscopic plants) and zooplankton (microscopic animals) biomass, as well as nutrient composition, is collected and analyzed in order to discern any major trends in ecosystem composition over time. Additional information to the summary below can be found in Pepin et al. 2011.

Nutrients (i.e., nitrate, phosphate, and silicate) are incorporated into phytoplankton during photosynthesis. The availability of nitrogen is hypothesized to be limiting to the growth of phytoplankton in the northwest Atlantic (Pepin et al. in Templeman 2010). Across the region, annual nitrate inventories (shallow and deep) have declined since 2008 and appear to be continuing to decrease in 2010. The inventory of nitrate within the upper 50 m and deep layers at S27 was the lowest observed since the start of the time-series in 1999.

Chorophyll concentrations can be used as an indicator of primary productivity. Chorophyll concentrations in 2009 were at their highest levels since the start of AZMP activities in the region, however, returned to near normal values in 2010. The magnitude of the spring bloom at S27 has been lower than normal since 2008, however, similar to the timing of the bloom the trend going into 2009-10 has been toward a return to average conditions. The duration of the bloom in 2010 based on sampling observations was only 14 days, the second lowest observed in the time-series compared to normal conditions of about four weeks.

SeaWiFS and MODIS satellites determine phytoplankton biomass through ocean colour (chlorophyll *a* concentration). This allows for a much greater portion of the northwest Atlantic Ocean to be studied compared to using sampling vessels alone. Seasonal data can also be collected this way allowing for detection of spring and autumn blooms. Bi-weekly composite images of surface chlorophyll for the entire NW Atlantic (39-62.5°N Latitude, 42-71°W Longitude) are routinely produced from SeaWiFS/MODIS data. The early developments of patchy surface blooms were observed through remote sensing of ocean colour on the south-eastern areas of the Grand Banks by early March 2010. This spring bloom intensified rapidly to cover the whole of the Grand Banks in late March with concentrations of chlorophyll *a* >10 mg m^{-3}. The bloom progressed northward in early April to cover much of the northwest Newfoundland Shelf while surface concentrations were greatly reduced on the Grand Banks (Fig, 5). This satellite data indicates slightly higher surface chlorophyll *a* concentrations across all sub-regions in autumn 2010 compared to average conditions.

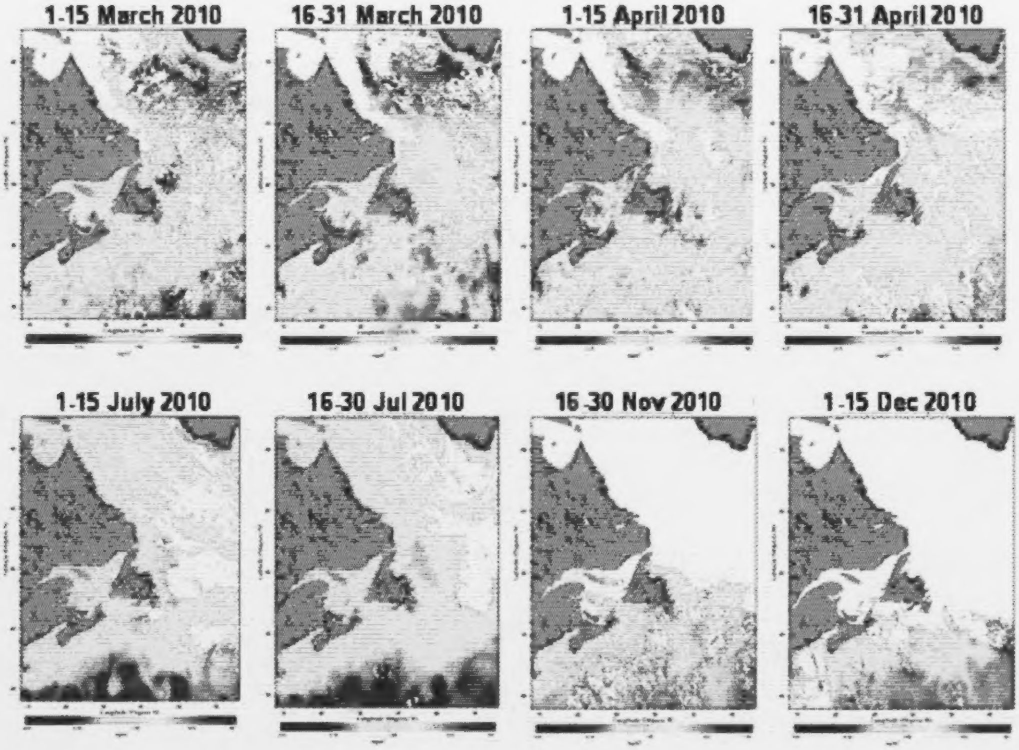


Figure 5. MODIS semi-monthly composite images of surface chlorophyll a concentrations in the NW Atlantic region before the start of the ocean monitoring program (March 2010 imagery) and during Atlantic Zonal Monitoring Program seasonal (April, July, November-December months) surveys in 2010. Data resolution is approximately 2 km per pixel (from Pepin et al. 2011).

In 2009 and 2010, the principal zooplankton indices indicated that abundance of this biological component was generally higher than average, with densities reaching their highest levels in 2010 along many of the oceanographic sections. There was evidence of a north-to-south gradient in the anomalies in zooplankton abundance in 2009 and 2010, with conditions nearer to the long term average in the north and higher than average in the region of the Grand Banks (S27, Flemish and southeast GB sections), however, this trend was not consistent for all zooplankton indices in all years. The abundance of *Pseudocalanus* sp. was high throughout the region in 2010 but the greatest increase occurred in the north relative to other parts of the Newfoundland Shelf.

The abundance of most large copepods at Station 27 in 2009 and 2010 has increased significantly since the low levels observed in 2008. The abundance of most small copepods, including, *Microcalanus* sp., *Oithona* sp., *Pseudocalanus* sp. and *Onacaea* sp. reached peak or near-peak levels while that of the warm

water species *Acartia* sp., *Centropages* sp., and *Temora longicornis* were at low levels of abundance.

Generally, the abundance of many species of zooplankton shows a strong seasonal trend with a single peak in mid to late summer, some time after the phytoplankton bloom.

Despite nutrient inventories across the region being generally at record low levels, the abundance of phytoplankton fluctuates substantially from year-to-year and the general trends in zooplankton abundance indicate that most taxa are above their long term (1999-2010) average. The pattern of variation of each trophic level demonstrates a high degree of regional coherence, with northern and southern portions of the Newfoundland and Labrador Shelf generally showing similar changes from year-to-year or over longer time scales, suggesting that coherent large-scale processes may be influencing the dynamics of lower trophic levels at the regional level. However, identifying the functional relationships with these processes is likely to require careful consideration of the broad variety of influential factors and of the possible complexity of interactions.

ECOSYSTEM SHIFTS

During the early 1990s a major shift in community structure occurred along the entire Newfoundland and Labrador shelf, including the LOMA. Changes included decreases in target and non-target groundfish abundance (e.g., Atlantic cod, American plaice, thorny skate, wolfishes), dramatic increases in the biomass of invertebrates (e.g., snow crab and northern shrimp), the reduction in availability and changes in the biology of capelin, as well as a continued increase in the harp seal population. The reasons for these changes are still under debate, but overfishing, climate changes and trophodynamics are some of the hypotheses used to explain them. Unlike the Scotian Shelf ecozone these changes did not coincided with any observed decrease in zooplankton or an increase in small forage species (DFO 2010a).

Many historically dominant groundfish declined to very low levels where they are currently at a small percentage of those previous. Along with Northern cod, other main commercial species also declined in the late 1980s and early 1990s, where fishing has been considered a major driver of many of these declines. Concurrent with high fishing pressure during this time, environmental conditions in the Northwest Atlantic were also severe, such that environmental conditions have often been suggested as additional drivers for the changes observed in fish stocks (NAFO 2010). Despite management measures to date, such as fisheries closures, significant increases in populations have not seen and the remaining individuals are often smaller at maturity. As a consequence of these declines some species have reached levels whereby they are being considered as a

'Species At Risk' by Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

In parallel with the last collapse of groundfish stocks, shellfish like northern shrimp and snow crab increased. It has been suggested that predation release from groundfish predation may be one of the causes behind these population increases, however, water temperature effects on early life history stages has also been explored as a possible explanation. Invertebrates have dominated the fisheries catches since the collapse of groundfish stocks in the early 1990s, with northern shrimp being the dominant species, followed by snow crab. The exploitable biomass of snow crab declined from the late 1990's to 2003. It increased from 2003-07 and has since been little change in this resource (DFO 2011b). The most recent assessment of Northern Shrimp showed a general increase in this resource until 2006, followed by decreases, and are at levels similar to levels of the early 2000s (DFO 2011a).

Among forage fishes, capelin has a dominant role in the Newfoundland Shelf food web. Forage fish species are the core links which transfer the energy from primary and secondary production to the upper trophic levels. They constitute important food items for large demersal fish like Atlantic cod, Greenland halibut and American plaice, marine mammals like harp seals and large whales, and seabirds like common murres and gannets. Capelin, a major forage fish in this system, also showed a dramatic decline in the early 1990s – and the abundance of capelin has remained low ever since. This decline was accompanied by significant changes in the species' biology (Carscadden and Nakashima 1997 in SCR Doc 10/019). Higher offshore abundance estimates of capelin from spring acoustic surveys between 2007 to 2009 complemented observations by fish harvesters that abundance had been increasing since 2006. However, abundance in 2010 was the lowest in the series, an order of magnitude lower than estimated for 2007-09 and less than 1% of historical levels (DFO 2010f).

Among marine mammals, harp seals are the single most abundant species in the Newfoundland Shelf system. Its main preys are capelin and Arctic cod, but harp also feed on a large set of species including flatfishes, Atlantic cod, and shrimps. The harp seal population declined during the 1960s, reaching a minimum of less than 2 million in the early 1970s. The population tripled by the mid-1990s to a very high level (~ 5.5 million). The harp seal population has continued increasing slowly for the last several years and was estimated to lie between 8.61- 9.55 million (95% CI 7.80 to 10.80 million) animals in 2010 (DFO 2011g).

ATLANTIC COD

Three stocks of Atlantic cod occur within the PBGB LOMA: Northern (2J3KL) cod, specifically a portion of 3L; Grand Banks (3NO) cod; and South Coast (3Ps) cod. All three of these cod stocks declined sigificantly in the late 1980s and early

1990s, however, to varying extents. Trends in abundance, biomass and condition are also variable across stock and area (inshore versus offshore). The following sections provide the most recent stock assessment data for each stock and a final section summarizing some of the information on the current knowledge of Atlantic cod habitat resulting from the Recovery Potential Assessment Zonal Advisory Process, held in February 2011.

Atlantic cod is now considered as six COSEWIC designated units (DUs), of which four have been assessed and designated as Endangered by COSEWIC: Newfoundland and Labrador, Laurentian North, Laurentian South, and Southern DUs. These four populations have diminished to the extent that they are predicted to experience serious or irreparable harm. In support of decisions for listing recommendations for Atlantic cod, DFO Science undertook a Recovery Potential Assessment (RPA) of each of the four endangered DUs during February 2011. The Science Advisory reports for all DUs, of which the Newfoundland and Labrador Desginatable Unit (NAFO Divs. 2GHJ, 3KLNO) and the Laurentian North Designatable Unit (3Pn, 4RS and 3Ps) have representation within the LOMA, can be found on the DFO Science Advisory Schedule at http://www.isdm-gdsi.gc.ca/csas-sccs/applications/events-evenements/index-eng.asp. Notably, the results of these RPAs are mainly based on projections of stock size over 36 years (three generations of Atlantic cod). Since future productivity conditions are very uncertain, these long-term projections should not be interpreted as forecasts of the future stock status as they depend on assumptions about future productivity and fishing mortality.

In advance of the RPAs undertaken for Atlantic cod, a Framework meeting was held in Newfoundland and Labrador in November 2010 with two objectives: (1) to discuss methodologies for the determination of reference points for Newfoundland cod stocks, and (2) to solicit views on methodologies for carrying out projections on Newfoundland cod stocks. Appropriate guidance for potential future applications of the information coming out of discussed approaches (e.g., Precautionary Approach; and RPA) was provided by DFO Fisheries and Aquaculture Management. The main focus of the reference point portion of the meeting was the determination of a limit reference point (LRP) for 2J+3KL (northern) cod. In addition, the existing LRP for 3Ps and 3NO cod were examined.

SUBDIVISION 3PS (SOUTH COAST) COD

In Fall 2010 a Regional advisory process was held to assess the current status of the 3Ps cod stock. The main objectives were to evaluate the status of the stock and to provide scientific advice concerning conservation outcomes related to various fishery management options. Additional information to the summary below can be found in DFO 2010d.

The 3Ps cod stock off southern Newfoundland extends from Cape St. Mary's to just west of the Burgeo Bank, and over to St. Pierre Bank and most of Green Bank. The cod stock in this area is complex, consisting of fish that migrate seasonally inshore and offshore as well as move between adjacent areas. This stock is assessed annually.

Biomass of 3Ps cod declined since the 1980's and reached an all-time low in the 1990's. There was a small increase in abundance in 2004 but this resulted in a population level no where near as high as levels during the 1980's. There was a general declining trend in the survey index from 87,000 t in 2001 to 20,525 t in 2008 (Fig. 6). The biomass index was higher in both 2009 and 2010 (57,450 t). Still, the abundance of mature individual cod is approximately 10 % below the 1983-2010 average.

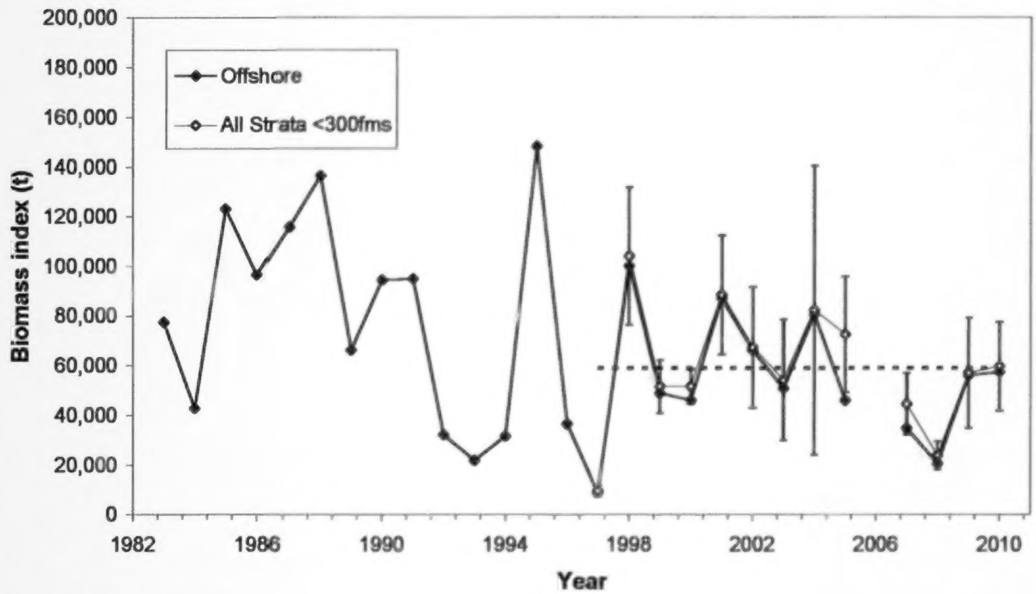


Figure 6. Research vessel survey biomass indices (t) (error bars are 95 % confidence intervals for combined survey index – dashed line is average of combined survey index) (DFO 2010*d*).

The 3Ps cod were heavily exploited until the 1980s when there was a sharp decline to record low levels of abundance in 1994. A moratorium was imposed in 1993, however the fishery reopened in 1997 with a TAC of 10,000 t. This increased to 20,000 t in 1998 and to 30,000 t in 1999. In 2000 the management year was changed to begin on 1 April. Reductions in TAC followed to 15,000 t for 2001-05, 13,000 t for 2006-09 and 11,500 t for the 2009-10 and 2010-11 management years. Under the Canada-France agreement, the French (St. Pierre et Miquelon) share of the TAC is 15.6 %.

The limit reference point (LRP, $B_{Recovery}$) for this stock is the 1994 level of spawning stock biomass (SSB). The current SSB is about 30 % less than the 1983-2010 average and is marginally above (7 %) the LRP (DFO 2011*d*). Short-term projection results indicate that SSB will increase if total mortality rates are similar to current values and that the probability of being below the LRP in 2011 is low (0.04-0.17). However, total mortality rates (mortality due to all causes, including fishing) estimated from recent cohort models averaged 0.60 (45 % mortality). This high level of mortality is a concern.

Notably, 3Ps cod have complex stock structures and migration patterns that must be considered in their assessment and management. There is evidence of offshore-inshore migration during spring and summer as well as the existence of an inshore population that is outside the DFO survey trawl throughout the year. Tagging and telemetry studies have confirmed cod moving into 3Ps during winter (peaking in December) with a peak in returns to 3Pn in the first two weeks of April. It has been recommended that fisheries management consider cod that overwinter in 3Ps may be exploited in other areas, and management in these areas (Div. 3L and 3Pn) could impact the 3Ps cod stock. A series of area/time closures has been introduced as a result of concerns about the migration patterns of the fish in this area. It is suggested that the consequences of these closures be considered as they may result in higher exploitation rates on components of the stock that remain available to fishing. One such seasonal closure has been introduced to protect spawning or mixed-stock aggregations. The timing of this closure is appropriate and should continue to reduce the impact on the 3Pn4RS stock.

DIVISIONS 2J+3KL (NORTHERN) COD

In 2011 a Regional advisory process was held to assess the current status of the Northern cod stock. The assessment reviewed ecosystem information, catches, trends in catch rate indices from surveys, harvest rates, and tagging studies. A portion of the northern cod stock management area in Div. 3L is found within the PBGB LOMA. Conclusions and advice are given on the stock as a whole as well as for offshore and inshore regions separately. Additional information to the summary below can be found in DFO 2011e.

Northern cod have a slower growth rate compared with those in the eastern Atlantic and further south in the Western Atlantic. Since the late 1980s females have been shown to be maturing at about age five, which is earlier compared to previous cohorts.

The Northern cod stock structure is complex and comprises several sub-components. Historically, the largest components of the stock overwintered in the offshore along the edge of the continental shelf. Recent tagging and telemetry studies indicate that although the offshore components are much less abundant, the historical shoreward seasonal migration pattern of the pre-moratorium period

occurred during 2008-10. Tagging studies have shown a substantial portion of cod from the offshore moving inshore to 3KL during 2008-10, rendering them vulnerable to the inshore fisheries. The estimated exploitation rate of offshore cod in the inshore ranged between 3 % and 6 % during 2008-10. Tagging studies from the late 1990s to the early- to mid-2000s also showed the 'inshore' component of the 3KL stock is composed of a resident coastal stock component, and a migratory component that overwinters in inshore and offshore areas of 3Ps, moves into southern 3L during late spring and summer, and returns to 3Ps in the autumn.

The total annual catch of cod in 2J3KL is uncertain but reported landings (excluding recreational fisheries) were 2,902 t in 2010. Since recreational fishery landings could be a substantial component of total removals, improving the management of these fisheries is recommended to allow total removals to be effectively controlled and directly measured, and more accurate catch information provided to evaluate the total impacts of fishing.

Trends in the overall status of Northern cod are based on DFO autumn RV survey data. Some improvement in stock status was observed during 2004-08, but this was restricted to a small portion of the overall stock area in the vicinity of the 3KL border, adjacent to Trinity and Bonavista bays. However, this recent increasing trend in total biomass and spawning stock biomass (SSB) has not continued where total biomass increased during 2004 to 2009 but remained the same in 2010 (Fig. 7), and SSB increased from 2004 to 2008 and remains the same at present. A conservation LRP has been established for this stock – since the early 1990s the estimated SSB has been well below the LRP and in 2010 was 90 % below the LRP. The stock is not expected to reach the LRP within the next five years at current levels of stock productivity (growth rates, recruitment, and survival).

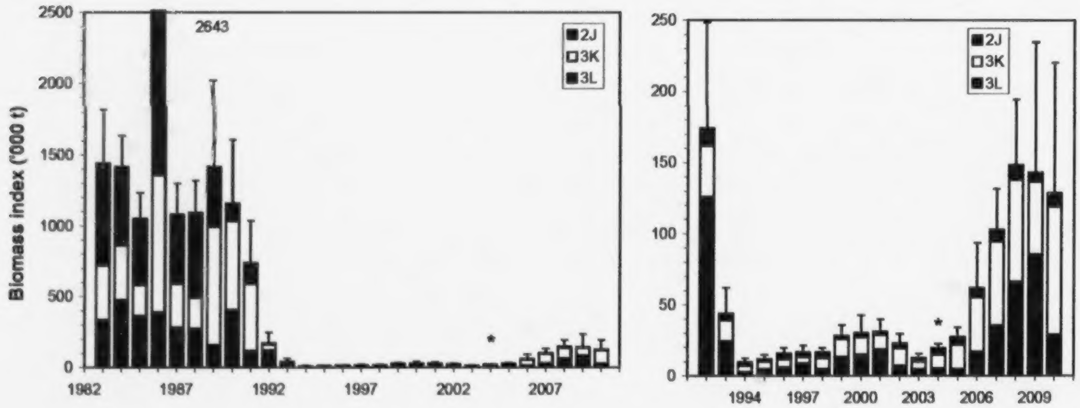


Figure 7. Offshore biomass index (+2 SE's) from autumn Research Vessel (RV) surveys in 2J3KL. The right panel is expanded to show trends from 1992 onwards. Asterisks indicate partial estimates from incomplete survey coverage of 3L in 2004 (DFO *2011e*).

During the recent RPA of the NL DU of Atlantic cod, a high level of natural mortality (in 2J+3KL) and fishing mortality (in 2J+3KL and 3NO) were identified as the greatest threat to the recovery of this population. In 2J3KL fishing mortality occurs primarily through directed stewardship and recreational fisheries and in 3NO as bycatch (DFO 2011*d*).

Predators and prey also play a role in the population dynamics of 2J3KL cod. Marine mammal populations (e.g., harp seals) can have a strong influence on cod populations through direct predation and added indirect consumption of key prey such as Capelin and shrimp. Analysis of cod stomachs sampled during RV autumn surveys suggest that Capelin (*Mallotus villosus*) and *Pandalus* shrimp are the main prey for cod (although they do consume a variety of invertebrate and fish species). The recent combined low availability of both these forage species in the ecosystem could impact the potential for recovery of cod.

3NO (GRAND BANKS) COD

Cod in Div. 3NO inhabit the southern Grand Bank within the LOMA. This stock is assessed and managed by the Northwest Atlantic Fisheries Organization (NAFO). Further information to the summary below can be found in NAFO documents including Morgan 2008 and Power et al. 2010.

There was a dramatic decline in the biomass of 3NO cod during the mid 1980s and although at a low level, biomass has experienced an improvement in recent years, to levels just prior to the moratorium. There has been no directed fishery both inside and outside the Canadian EEZ for 3NO cod since the moratorium in

1994. Still, substantial levels of cod are caught as by-catch in other fisheries, such that this was identified in the recent Recovery Potential Assessment (RPA) as the greatest threat to recovery (DFO 2011*f*). It has been noted that fishing mortality has been declining since 2006.

In 2007 the Fisheries Commission of NAFO developed a conservation and rebuilding strategy for 3NO cod which aimed at attaining a sustained level of Spawning Stock Biomass (SSB) or a recovery milestone above 60,000 t (Blim), consistent with the NAFO Precautionary Approach Framework. To initiate rebuilding under the strategy, for 2008 onward, fisheries were to aim to achieve a targeted reduction of 40 % from the average annual catch during the 2004-06 period or, through best efforts, specifically to keep incidental by-catch at the lowest possible level. However, the NAFO Scientific Council has estimated that catches of 3NO cod have been about 900 t in 2008, 1,100 t in 2009 and 950 t in 2010 – this represents an increase of 32 %, 55 %, and 36 %, respectively, compared to the average annual catch during the 2004-06 period (NAFO 2011a).

In 2008 an investigation was undertaken by the NAFO Scientific Council to determine the spatial distribution of 3NO cod and to determine if there is a possible means of decreasing by-catch. In this, cod were found to be widely distributed in this area for both the spring and fall surveys, with no consistent areas of high concentrations. Therefore it is difficult to minimize by-catch through restricting fishing to specific areas. Since it has been reported that the Yellowtail flounder fishery accounts for almost 80 % of cod by-catch, and is highest at specific times of the year, by-catch of 3NO cod may potentially be decreased by limiting the Yellowtail fishery during certain months.

Recruitment of 3NO cod remains low but has been improving in recent years with current estimates of the 2005-07 year classes comparable to those from the mid-late 1980s. The estimated SSB has been and continues to be well below the LRP since the early 1990s, and even with the recent increase it is currently 79 % below the LRP (B_{lim}).

ATLANTIC COD - HABITAT

At the recent Recovery Potential Assessment of Atlantic cod stocks, habitat was considered in terms of overall habitat requirements and suitability within the context of recovery potential of Atlantic cod (applicable to all stocks within the LOMA). The information below was taken from the Recovery Potential Assessment SARs for the Newfoundland and Labrador Designatable Unit (NAFO Div. 2GHJ, 3KLNO) and Laurentian North Designatable Unit (3Pn, 4RS and 3Ps).

Habitat use by Atlantic cod varies with life stage and size. Atlantic Cod assume more active control of their movements at the pelagic juvenile stage, however, it

is unknown to what extent individual cod display directional movements influencing where they settle to the seabed. The demersal juvenile stage (4-35 cm long) is the most habitat-dependant period in the life-cycle of Atlantic Cod. The area of settlement may be related to temperature conditions which affect growth. Pebble-gravel and rock-boulder areas situated within a patchy marine landscape are significant habitats for demersal juveniles in both inshore and offshore areas. Evidence does suggest that juvenile cod do saturate local habitat and their densities affect recruitment to subadult life stages. Adult Northern cod (2J3KL) are associated with specific bathymetric features near the shelf break, and other areas with high prey concentrations. Distribution of adult cod in 3Ps is likely determined primarily by temperature and food availability. For adult cod overwintering areas tend to be in deeper warmer waters. There is thought to be an association between spawning locations and oceanographic features such as gyres or currents that retain eggs and larvae, or distribution of them to locations where conditions are generally good for early life-history stages. Having specific spawning locations that are stable over time, suggests there are distinctive features about these locations leading spawning cod to select them repeatedly.

Older juvenile and adult Atlantic cod are distributed throughout the Canadian portion of the historical range of the species, indicating that some amount of suitable habitat exists within this range.

Notably, knowledge of the amount and spatial distribution of available habitat (i.e., gravel and cobble, eelgrass beds or macroalgae) for demersal juvenile Atlantic Cod is currently unavailable at the spatial scales with which juveniles are thought to be utilizing it. The spatial resolution of most of the available seabed habitat knowledge is on the order of tens of kilometers. In contrast, demersal juvenile cod are known to associate with seabed habitats at scales of hundreds of meters and less. This creates a discrepancy of scale on the order of 100 to 1, especially in the offshore. There is no indication that the amount of suitable habitat is currently limiting recovery of cod.

It has also been noted that the physical disturbance of structural components of habitat utilized by the species can reduce its value and increase mortality of juvenile cod. Activities identified that might threaten habitat, to varying degrees include: mobile bottom-contact fishing gears, other fishing gears, eutrophication in areas of the nearshore and in some areas of the inshore, and oil and gas development resulting in physical disturbance or contamination of habitat. There is a tremendous ecological significance of complex habitat to the survival of demersal juvenile cod. In eelgrass beds, a reduced landscape complexity leads to reduced demersal juvenile densities and carrying capacity within habitat. However, the impact of reduced landscape complexity for other habitat components is unknown.

CETACEAN (WHALE, DOLPHIN AND PORPOISE) DISTRIBUTION AND ABUNDANCE

During the summer of 2007 DFO research scientists conducted a large scale aerial survey in order to accurately estimate the abundance and distribution of marine mammals, sea turtles, and other surface megafauna. This was the first time such a survey has been conducted in two decades for the Newfoundland and Labrador Shelf. This information is key to accurately assessing the status and distribution of marine mammals, and will have significant impacts on our understanding of cetaceans from management and Species at Risk perspectives. Additional information to the summary below can be found in Lawson and Gosselin 2009.

Since cetaceans are long-lived and have slow reproduction rates, they are especially vulnerable to exploitation and impacts. As such, large-scale surveys are important to supply current information on distribution and abundance of whale stocks and mega fauna to better inform conservation and management of these species. Data gained in the 2007 and other DFO surveys (all included in a large database extending back more than 100 years) will be integrated with European and American surveys to provide information for the entire north Atlantic with the Grand Banks and Scotian Shelf as areas of interest for Canada.

Eighteen different cetacean species were identified during the survey, totaling almost 4,000 individuals. The humpback whale (*Megaptera novaeangliae*) was the most commonly sighted cetacean on the Newfoundland Shelf, and the white-sided dolphin (*Lagenorhynchus acutus*) was the most abundant species. High numbers of fin whales (*Balaenoptera physalus*) and white-beaked dolphins (*Lagenorhynchus albirostris*) were also recorded.

For smaller cetacean species like the common dolphin (*Delphinus delphis*) and the harbour porpoise (*Phocoena phocoena*) the abundance estimates were low compared to surveys done in previous years. This could be a function of a late arrival of fish and cetacean species into Newfoundland waters; a hypothesis supported by fishery officers, fishers, and members of the tourism industry who claim marine mammal sightings occurred later that year.

In terms of distribution and abundance, the south coast of Newfoundland had the highest density and species diversity of cetaceans sighted during effort surveys in NL (Fig. 8). In particular, the PBGB LOMA is the richest area for cetaceans. Relative to other parts of the province, these animals were most numerous off the south coast of Newfoundland - particularly late in the summer and the early fall. SARA-listed species sighted in this area historically include blue whales (*Balaenoptera musculus*), northern right whales (*Eubalaena glacialis*), fin whales, and leatherback sea turtles (*Dermochelys coriacea*).

SEA TURTLE DISTRIBUTION AND RELATIVE ABUNDANCE

The PBGB LOMA is also the richest area for jellyfish-eating species such as leatherback sea turtles and sunfish (*Mola mola*). Relative to other parts of the province, systematic surveys and historic sightings data have shown that these animals were most numerous off the south coast of Newfoundland in the summer and early fall, as their prey base of jellyfish reaches its maximum abundance and dispersion.

Figure 8. Aerial survey effort and sightings during DFO's portion of the 2007 TNASS survey. Newfoundland and Labrador (yellow, light green, and light grey), Cape Breton (purple), Scotian Shelf (pink), and Gulf (light blue) blocks. Marine megafauna sightings made during the Canadian aerial survey effort are indicated with blue circles (Newfoundland and Labrador) and red squares (Cape Breton, Scotian Shelf, and Gulf) (Lawson and Gosselin 2009).

AQUATIC INVASIVE SPECIES (AIS): GREEN CRAB

With the potential for AIS to impact biodiversity, aquaculture or fisheries resources, and species at risk, AIS are now considered one of the lead threats to native biodiversity. Currently, four aquatic invasive species have been confirmed to inhabit the waters within the LOMA. These include the violet tunicate, golden star tunicate, coffin box bryozoan and the green crab (*Carcinus maenas*). A

conservation priority identified for the LOMA is the control of green crab. Additional information to the summary below can be found in DFO 2010b.

The green crab is an invasive species native to Europe and northern Africa. Reported in the Maritimes since the 1950's, the species was only recently reported in North Harbour, Placentia Bay, Newfoundland for the first time in 2007. Figure 9 illustrates where ecological assessments have been conducted and areas with presence of green crabs are indicated.

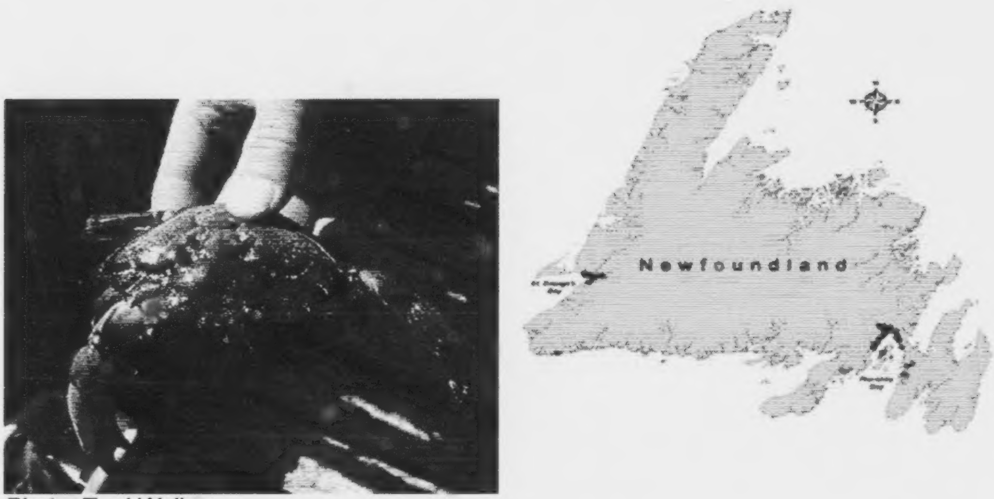


Photo: Terri Wells

Figure 9. Map of the Newfoundland Region where ecological assessments were conducted. Red areas indicate green crab presence (DFO 2010*b*).

A DFO Regional Advisory Process was held March 2010 to review the current scientific knowledge related to green crab populations in Newfoundland, to assess the potential biological impact of green crab populations in Newfoundland, to assess the potential biological impact of green crab on biodiversity and habitat, and to report and compare the effectiveness of trapping as a control method in Newfoundland. The European green crab population is established in extremely large concentrations in northern Placentia Bay and is spreading at a rapid rate throughout the bay. Populations have also been established in St. George's Bay on the western side of the island. Anthropogenic activity through vessel traffic is the most likely vector of introduction into the Region. Accurate population density estimates for green crab is a critical knowledge gap and is information vital to setting levels for response measures, thresholds for impact and measuring the success of control efforts.

In areas of high green crab abundance, the impact of this invasive species is substantial on commercial and noncommercial mollusk and crustacean species and the natural environment. As is the case in other regions affected by green

crab, shellfish are determined to be the predominant prey in the Newfoundland environment. The predation of American lobster (*Homarus americanus)* is a significant concern as gut content analysis, laboratory trials and anecdotal reports indicate that green crab can and do prey on juvenile and trapped adult lobster. It has been shown that in many areas of North America, the burrowing behavior of green crabs for shelter and digging for prey in eelgrass beds substantially reduce the amount of eelgrass and reduce coverage of this ecologically and biologically significant habitat. The threshold levels for impact or critical number of green crab per area has not been determined and is vital to the complete understanding of potential for impact.

Mitigation by removal of green crab through intense trapping can be an effective method of reducing the abundance of green crab and limiting the impact the species has on the environment. While intense trapping seems to be an effective control method, threshold levels of population densities, timelines for action relative to impact, and measures of success will need to be well-defined based on specific environments.

Further information on green crab and other AIS found within Newfoundland waters (and the PBGB LOMA), including the violet tunicate (*Botrylloides violaceus),* golden star tunicate (*Botryllus schlosseri*), and coffin box bryozoan (*Membranipora membranacea*), can also be accessed at http://www.nfl.dfo-mpo.gc.ca/AIS-EAE.

HABITAT

While there still remain many unknowns on the classification and availability of the various habitat features within the LOMA, the identification of EBSAs and ESSs (specifically those identified as providing structural habitat) contributes to the knowledge of areas that are important to the ecosystem structure and function through their contribution to habitat. In recent years, significant advances have been made in identifying these significant areas and species within the Region, including the LOMA.

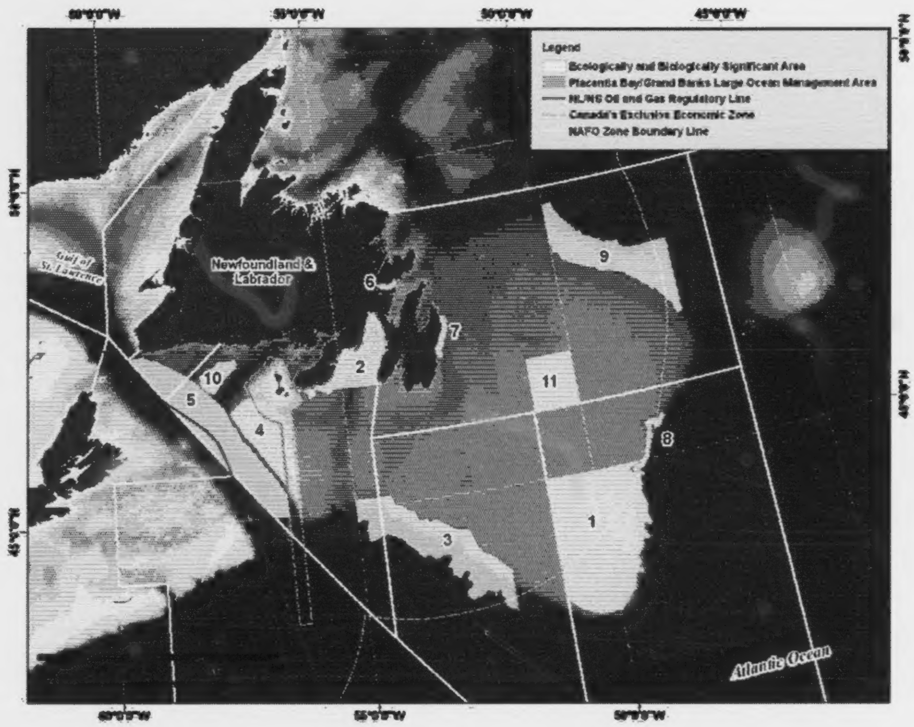
The identification of EBSAs is considered a useful tool for bringing attention to areas that have some particular ecological or biological significance, and focuses attention on the area allowing a greater-than-usual degree of risk aversion in the management of activities. Eleven EBSAs have been identified in the LOMA.

Ecologically significant species were identified among the COs for the PBGB LOMA (DFO 2007). Structural species identified within this category included eelgrass and corals. Deep-sea corals are important components of benthic habitats, contributing to structure and species diversity (*see Deep-sea Corals below*). Eelgrass, constituting a dominant habitat feature has a measurable

influence on the overall ecology of marine ecosystems, and in eastern Canada has recently met the criteria of an ESS.

ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS (EBSA)

In 2007, following National DFO guidelines outlined in the Canadian Science Advisory Secretariat (CSAS) DFO 2004, a process was carried out to identify EBSAs for the PBGB LOMA. Based on the best available information at the time, a total of eleven EBSAs were identified and evaluated for the PBGB LOMA (Fig. 10).



Key: EBSAs in order of Significance	
1. The Southeast Shoal and Tail of the Banks	7. Eastern Avalon
2. Placentia Bay Extension	8. Lilly Canyon-Carson Canyon
3. The Southwest Shelf Edge and Slope	9. Northeast Shelf and Slope
4. St. Pierre Bank	10. Burgeo Bank
5. Laurentian Channel and Slope	11. Virgin Rocks
6. Smith Sound	

Figure 10. Placentia Bay-Grand Banks Large Ocean Management Area: Ecologically and Biologically Significant Areas. (Provided by Ecosystems Management, NL Region).

Detailed information on the significant ecological and biological properties of these areas in the LOMA were evaluated for their relevance to the primary dimensions of Uniqueness, Aggregation, and Fitness Consequences, and summarized in an EBSA matrix. Information related to the secondary dimensions of Resilience and Naturalness for the EBSAs was also noted within the matrix and can be found in Temple man (2007). Several caveats should be noted with the identification of these areas, among them: potential bias towards data rich areas versus data poor areas, and areas that do not qualify as EBSAs within this framework should not be considered to have no ecological or biological importance.

Recently, a National Science Advisory Meeting was held to examine the lessons learned throughout the application of national guidelines to identify EBSAs within DFO's five LOMAs across the country. EBSAs previously identified through this process have been considered and applied within a number of management contexts to date, including for integrated management within the LOMAs. With efforts on-going to identify EBSAs outside of the LOMAs, it is timely to review and adjust previous EBSAs guidance, for among other issues, data deficient areas.

Laurentian Channel Area of Interest (AOI)

An example of EBSA application for integrated oceans management is the Laurentian Channel AOI. Following the identification of the 11 EBSAs in the LOMA, stakeholder and public consultations took place regarding the consideration of these areas for next steps in applying additional spatial and/or temporal based management measures in the area. On June 8, 2010 the Minister of Fisheries and Oceans announced the Laurentian Channel in the NL Region as an AOI for potential MPA establishment.

Subsequent to this, a DFO Regional advisory meeting was held in November 2011 to develop a biophysical overview of the Laurentian Channel AOI. The resulting report contains information on the biophysical attributes of the area and may be used to aid the Department in refining conservation objectives, delineating boundaries, and determining if in fact an Oceans Act MPA is the appropriate management tool for the site. The full details of this report can be accessed at DFO 2010e.

Sensitive habitat in the AOI includes various species of corals. Specifically, sea pens have been recorded in the concentrations within the Laurentian Channel (just west of the study area). Various marine species such as cetaceans, sharks, fish, and leatherback sea turtles also use the area for various life functions, including foraging, mating grounds, and migratory routes. The report highlights information that was not available for inclusion in the biophysical overview including, groundtruthing of benthic habitat, e.g., corals, sponges and potential

[preferred] habitat associations for many of the species considered, and the influence of scale on these.

ECOLOGICALLY SIGNIFICANT SPECIES (ESS)

An ESS is defined as one that "if perturbed severely, the ecological consequences (in space, in time, and/or outward through the food web) would be substantially greater than an equal perturbation of most other species or community properties" (DFO 2006). This definition also includes structural species that contribute to the complexity of the ecosystem and are used preferentially by other organisms. ESS should be provided advanced protection from human activities to ensure they maintain their contribution to ecosystem structure and function.

Eelgrass

A 2009 DFO National Advisory Process was held to discuss the role of eelgrass in the coastal and estuarine environments of Atlantic Canada in order to determine if eelgrass meets the criteria for constituting an ESS. The review assessed the quantity of eelgrass present, its distribution and abundance, and the significance of its structural habitat to the overall structure and function of the ecosystem. Additional information to the summary below can be found in DFO 2009.

Eelgrass beds are one of the most productive environments in the world in terms of primary productivity where they form extensive underwater networks providing a crucial habitat that reduces local currents, provides protection from predation, stabilize the sediment, filter water, and increases habitat complexity. Eelgrass typically occur in sheltered environments in depths where light can penetrate, enabling photosynthesis.

It has been highlighted that at least 20 different obligate species of algae depend on eelgrass meadows to complete their life cycles; while numerous non-obligate species have also been found in association with eelgrass. There are no known obligate fish species associated with eelgrass beds, but this habitat has been proven to support a higher diversity and density of fish species compared to unvegetated bottoms, throughout its range. Eelgrass beds are also important nursery grounds for some fish species including Atlantic cod in northeast Newfoundland. Additional evidence exists that predation rates are lower in eelgrass beds and that several temperate fish species, such as Atlantic cod, have had higher growth rates reported in eelgrass beds.

Eelgrass is distributed all around Newfoundland in protected bays and inlets to depths ranging from 0 m to 8 m, with the greatest abundances occurring on the

southwest coast. Eelgrass is not found in abundance in Labrador likely due to cold water temperatures and ice conditions. The recent introduction of the invasive green crab (see *Invasive Species* section) has potential to significantly impact eelgrass habitats, primarily through burrowing behaviour in search of food among the root system of eelgrass plants. Notably, while eelgrass is on the decline in many areas worldwide, eelgrass habitats in Newfoundland appear stable. In some areas of Newfoundland eelgrass habitats are increasing in scale, possibly due to an increase in favorable conditions such as reduced ice scour, and milder temperatures.

In most cases today, loss of eelgrass habitat is directly linked to anthropogenic stress; losses are greatest in close proximity to urban areas or enriched runoff. Variability in eelgrass structure is also observed with climactic events like temperature change and sea-ice cover, and recently, green crab invasions. In eastern Canada the impacts of these stressors on eelgrass community structure is not well studied.

DEEP-SEA CORALS AND SPONGES

As mentioned in the previous section deep-sea corals are important components of benthic habitats, contributing to structure and species diversity. Consequently corals and sponges have been recognized as one of the four conservation priorities in the LOMA. Regionally, the importance of research has been recognized and new partnerships and initiatives have developed increasing the knowledge of corals and sponges in the NL region in recent years. Priority research areas for deep-sea corals based on areas of high biodiversity and abundance have been identified in the region and management measures targeting their protection are ongoing.

Research in support of National initiatives for corals is conducted regionally through collaboration with DFO Science and Memorial University/Oceans Science Centre and industry, providing information, including, but not limited to; distribution information of corals; Sponge ID Guide similar to the NAFO Coral ID Guide; reproduction studies on corals, and coral monitoring program guidelines for incorporation into current industry research surveys.

Cold water sponges (*Phylum porifera*) are increasingly being recognized as important components of benthic marine ecosystems by providing habitat structure. Whereas the primary criteria for identifying Vulnerable Marine Ecosystems (VMEs) has previously been linked to high diversity and/or biomass of cold-water corals, sponges are now included as important VME components. As such, work is now being carried out by NL DFO Science to increase Regional expertise in the identification of sponges (e.g., taxonomic identification booklet similar to the NAFO Coral ID Guide), and aspects of their biology and ecology.

DEEP-SEA CORALS RESEARCH

The year 2003 marked the formation of the NL DFO-Memorial University Deep-Sea Corals Research Group and the subsequent dedicated deep-sea corals research program. Initially, research under this program focused on specimens collected as trawl bycatch during DFO multispecies surveys and the Observer Program. The program was expanded in 2005-08 with International Governance Strategy (IGS) funding supporting novel laboratory and field work. These studies aimed to answer many questions relating the importance of deep-sea corals to the structure and function of ecosystems, including their distribution, relationship between corals and fish species, and trophic relationships. The results of the different studies on coral biochemistry, habitat, and geography were combined into a DFO technical report published in 2009 by Gilkinson and Edinger (Eds.). The following information and two sections below (i.e., Relationships between Deep-Sea Corals; Coral Conservation Measures) are a summary from that report. Additional information to the summary below can be found in the report, Gilkinson and Edinger (Eds.) 2009.

Continued IGS support to the research group has funded two dedicated deep-water research cruises using the Remotely Operated Platform for Ocean Science (ROV ROPOS) in 2007 (SW Grand Bank slope) and in 2010 (Flemish Cap and Orphan Knoll – areas adjacent to the LOMA but not within). These cruises facilitated *in-situ* studies of deep-water ecosystems supporting corals and included the first study of a seamount in the region. In 2009, ecological and taxonomic studies of deep-water sponges were added to the research program since sponges, along with corals, are now recognized as components of VMEs. A National Centre of Expertise for Cold-Water Corals and Sponge Reefs was established out of the NL Region in 2008 with the intent to centralize the coordination and support for national and international efforts for coral/sponge conservation. For example, the NL Coral Sponge Research Program is working with the CoE in the compilation of Coral/Sponge Conservation Strategy for the east coast of Canada. For the purposes of this report deep-sea corals and cold water corals are interchangeable.

For some time deep-sea corals have been considered to represent ecologically significant species group of deep-sea ecosystems as they provide unique habitats important for many invertebrate and fish species. Cold water corals, the type of coral found in the Northwest Atlantic waters, have very slow growth rates and extreme longevities, making them exceptionally sensitive to the impacts of fishing gear and other bottom disturbances. Although significant progress has been made since 2003 in the NL Region, due to the historic lack of information on coral distribution and biology in local waters, further research is required in order for DFO to properly manage the conservation of Regional coral species.

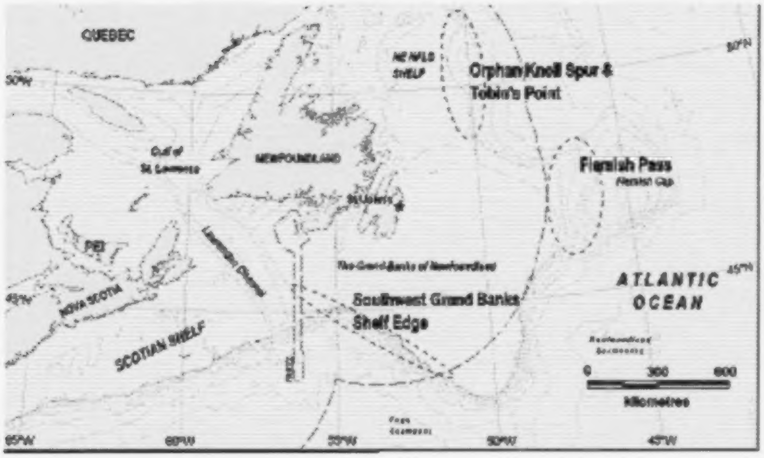


Figure 11. Priority research areas for deep-sea corals based on high diversity and abundance in the southern area of the Newfoundland and Labrador Region (modified from Gilkinson and Edinger (Eds. 2009)).

Relationships Between Deep-sea Corals and Groundfish

Relationships between deep-sea corals and groundfish have not been studied extensively in the Northwest Atlantic. However, Edinger et al (2009) showed that coral biomass and fish biodiversity were significantly correlated, as were coral species diversity and fish species diversity. With some exceptions, most fish species did not show any preference for specific coral species and patterns of distribution and abundance were not consistent with depth.

The majority of fish species studied were most abundant in sets with soft coral species, especially in shallow waters of less than 400 m. Notably, few species had greatest abundances in sets where large gorgonian/antipatharian corals dominated. The finding from this research suggests soft corals, sea pens and small gorgonians are of importance to fish and invertebrate species in the Region.

Finally, studies on the relationships between deep-sea corals and groundfish suggest that corals currently being recovered and recorded are much smaller than corals caught ten years ago from commercial trawlers. These findings are consistent with the trend in the exponential decline in coral wet weight and abundance in trawl fisheries over time.

Coral Conservation Measures

To date there have been several dedicated areas in the Region that have been closed to fishing due to the presence of corals – several of which occur within the PBGB LOMA (NAFO 2011b). One of the closures is an interim management measure within the NAFO area 3O whereby trawling at depths of 800-2000 m is prohibited until 2012. While this area extends all along the 3O slope between the boundaries of 3Ps and 3N, important *Keratoisis* species occurring in NAFO Div. 3Ps are not protected. It has also been observed that depths less than 800 m (particularly 400-800 m) provide important habitat for many long lived gorgonian and antipatharian corals; species which are therefore also not protected by the restrictions of this particular conservation measure. Another interim management measure restricts all bottom fishing activities as of January 1, 2010 until December 2011. This measure is in effect for the areas referred to as Tail of the Grand Bank (NAFO Div. 3N), Flemish Pass/Eastern Canyon (NAFO Div. 3LN) and the Sackville Spur (NAFO Div. 3LM). Only a small portion of the latter area extends inside the boundary of the LOMA.

Recommendations coming from Gilkinson and Edinger (Eds.) (2009) suggest that DFO continue its commitment to deep-sea coral research and further explore collaborative opportunities with the European Union and U.S. researchers to investigate priority research areas as a means to enhance our knowledge of this significant species group and to highlight opportunities for conservation. Priority areas were identified based on high diversity and abundance in the Newfoundland and Labrador Region and in the LOMA and include the Flemish Pass and Southwest Grand Banks Shelf and Edge (see Fig. 11), among others. Efforts continue in this direction – notably, a recent ROPOS cruise (2010) surveyed deep-water areas around Flemish Cap and Orphan Knoll (adjacent to the LOMA).

Within the LOMA there is a closed area to all bottom fishing activities in an area referred to as the Newfoundland Seamounts. The majority of this closed area is contained within NAFO Division 3M but does extend into NAFO Div. 3N (inside the LOMA boundary). This management measure is in effect until December 31, 2014 (NAFO 2011b).

CONCENTRATIONS OF CORALS AND SPONGES

A methodology developed within NAFO for the determination of significant concentrations of coral and sponge taxa was applied to Canadian waters on the east coast of Canada. Concentrations of sea pens, small and large gorgonian corals and sponges on the east coast of Canada have been identified through spatial analysis of research vessel survey by-catch data following the NAFO approach. Kernel density analysis combined with an assessment of patch size

change was used to identify high concentrations. Additional information to the summary below can be found in Kenchington et al. 2010.

These analyses were carried out for each of the five biogeographic zones of eastern Canada, including the Newfoundland Labrador shelves Biogeographic region. The PBGB LOMA exists entirely within this biogeographic region. Comments below address the analysis and concentrations of corals and sponges within the Newfoundland Labrador shelves Biogeographic region and specifically the LOMA were possible.

The coral database for this bioregion contains 38 coral taxa; 61 % of the records were soft corals belonging to family Nephtheidae, 18 % were sea pens, 9 % were large gorgonians (species of *Paragorgia*, *Primnoa*, *Keratoisis* amongst others), small gorgonians (species of *Acanella* and *Anthothela*) accounted for 7.4 % of the records, with black corals (antipatharians) comprising 0.01 % of the records and small cup corals (solitary scleractinians) comprising 0.04 %. Plots of the location of coral bycatch from research vessel and other surveys show all taxa other than the Nephtheid soft corals to be largely associated with the continental slopes.

Sea pens are present along the Laurentian Channel as determined from spatial analysis of survey vessel by-catch data. The largest catches of small gorgonian corals were found on the NL Shelf with two "significant" locations (of the three located in the bioregion) within the LOMA, located on the slope of the Grand Banks. Significant concentrations of large gorgonian corals are located within the LOMA along the continental margins. The distribution of large gorgonian corals may be incomplete if the annual stock assessment surveys exclude rough bottom from their station allocations where the gear could be lost. It is these rough bottoms that are often preferred by large gorgonian corals. However, this data has good spatial and temporal coverage to 1500 m. Areas below 1500 m and in coastal waters along the Labrador coast are not sampled and the former areas may hold significant concentrations of corals.

A large by-catch of sponges was reported from the continental slopes in the Newfoundland Labrador shelves Bioregion. The interpolated density maps show that sponges are found throughout the NL area, however increase northwards with no large aggregations on the Grand Banks or shelves. There are large areas of the Grand Banks that have no sponges.

NATIONAL INITIATIVES FOR CORALS

Corals and sponges form complex, three dimensional biogenic structures that directly and indirectly influence the occurrence and abundance of many fish and invertebrate species. It is known that corals, sponges and hydrothermal vents are sensitive and susceptible to anthropogenic activities, including direct (e.g.,

removal or damage) and indirect (e.g., smothering by sedimentation) fishing impacts. A national science advisory process was convened in March 2010 to review the available information, and provide science advice, concerning the occurrence, sensitivity to fishing, and ecological function of corals, sponges, and hydrothermal vents in the Canadian Exclusive Economic Zone (EEZ). A suite of ecological indicators were reviewed (i.e., uniqueness, rarity, species density, species richness, species distribution, and species diversity) and their strengths and weaknesses discussed. Three methodologies (i.e., cumulative distribution, area of aggregation, and species distribution models) were considered appropriate predictors of several ecological indictors (DFO 2010c). Elements to consider when developing an encounter protocol were briefly discussed and it was suggested that this be revisited in detail at a future science advisory process. Another national science advisory meeting was held in March 2011 to provide advice on the ecological considerations relevant to the development of a science-based encounter protocol framework for corals and sponges in Canadian waters. The full details of this advice can be found in DFO 2011f.

A National Center of Expertise for Cold-Water Corals and Sponge Reefs has been established at the Northwest Atlantic Fisheries Centre, with the purpose of coordinating the Government of Canada's approach to coral/sponge conservation, providing strategic advice to regional, national, and international efforts to protect corals/sponges and to develop tools and approaches to improve coral/sponge conservation. This CoE relies heavily on scientific advice and guidance for direction in the development of tools and strategies in support of coral and sponge conservation, and as such, can play a key role in identifying areas requiring further information from a management context. As communication is also a key aspect of the Center, several products supporting this role have been developed over the course of its existence, including a WebAtlas (i.e., distribution information of corals), educational DVD "Diving into the Deep", and presentations. The Newfoundland and Labrador/Eastern Arctic coral conservation strategy is being drafted with a planned release date of 2012.

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